Issued by the Colonial Office

EAST AFRICAN AGRICULTURAL RESEARCH STATION

AMANI

FOURTH ANNUAL REPORT 1931-32

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1932

COLONIAL No. 78

Price 1s. 0d. Net

88-301-78

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EAST AFRICAN AGRICULTURAL RESEARCH STATION AMANI

Report for the Period 1st April, 1931, to 31st March, 1932.

STAFF LIST.

Director.—W. Nowell, C.B.E., D.I.C., F.L.S.
Plant Pathologist.—H. H. Storey, M.A., Ph.D.
Entomologist.—T. W. Kirkpatrick, M.A., Dipl. Agric. (Cantab.), F.E.S.
Soil Chemist.—G. Milne, M.Sc., F.I.C.
Biochemist.—R. R. Le G. Worsley, A.R.C.S., B.Sc., Ph.D.
Plant Physiologist.—F. J. Nutman, A.R.C.S., M.Sc., D.I.C.
Plant Geneticist.—L. R. Doughty, B.Sc. (Agric.), N.D.A.
Superintendent of Plantations.—F. M. Rogers.
Secretary and Librarian.—R. E. Moreau.
Botanist.—P. J. Greenway, F.L.S.
Assistant Superintendent of Plantations.—K. E. Toms.
Assistant Secretary and Librarian.—W. M. Nutter.
Engineer-Mechanic.—T. V. Greenwood.
Laboratory Assistant (Pl. Path.).—R. F. W. Nichols.
Laboratory Assistant (Soil Chem.).—W. E. Calton, B.A., Dip. Agric.
Stenographer.—(Miss) K. Rushworth.

LEAVE MOVEMENTS DURING THE YEAR.

	Departed.	*Returned.*
Mr. G. Milne	—	7th October, 1931.
Mr. F. J. Nutman ...	15th April, 1931.	20th December, 1931.
Mr. F. M. Rogers ...	—	15th September, 1931.
Mr. P. J. Greenway ...	15th April, 1931.	31st December, 1931.
Mr. T. V. Greenwood ...	26th November, 1931.	—
Mr. W. M. Nutter ...	15th March, 1931.	—

CHANGES OF STAFF.

Mr. T. W. Kirkpatrick arrived on 12th August, 1931, to fill the post of Entomologist which had been vacant since the departure of Mr. C. B. Williams in 1929.

The appointment of Capt. E. M. Nicholl, Manager of Kwamkoro Coffee Estate, was terminated on 31st May, 1932.

Acting Duties.

Mr. K. E. Toms acted for the Superintendent from the beginning of the year until 15th September, 1931.

REPORT OF THE DIRECTOR.

GENERAL.

During the first three quarters of the year the staff of the Station was depleted by the absence on leave for long periods of the Superintendent of Plantations, the Soil Chemist, the Physiologist, and the Botanist. With the return of the last two of these officers in December, 1931, unity was restored and, so far as the senior officers are concerned, will be preserved, save for the absence of the Geneticist, until March, 1933. The opportunity thus presented for co-ordinated work occurs only once during a period of three years, roughly speaking, and is correspondingly valuable, while each member of the staff is enabled to give full attention to his own share of the formidable list of investigations included in the five-year plan.

The personnel of the staff, as at present constituted, was completed by the assumption of duty as Entomologist by Mr. T. W. Kirkpatrick in August, 1931. The selection of the main line on which entomological research is to be pursued was left open by the Amani Conference of 1931 until Mr. Kirkpatrick should have had the opportunity of surveying the field which the East African Dependencies present. After a comprehensive series of tours a scheme was submitted for the investigation of the relation between environmental conditions and the prevalence of specific insect pests of crops. This scheme, after consideration by the local Directors of Agriculture and the Colonial Advisory Council, was adopted. A beginning has been made with the study of climatic influences on the pests of coffee in Kenya, for which purpose Mr. Kirkpatrick has been stationed at Kiambu, where he will have the important advantage of ready consultation with the Director of the East African Meteorological Service, who has promised his assistance.

The most important addition to the equipment of the Station in its widest sense is the provision in the road to Amani of an entirely new section which follows the alignment of the Sigi Railway, now finally abandoned and dismantled. This displaces, over a distance of some ten miles, the most difficult and trying part of the old road and substitutes a track with long easy gradients and wide curves. The distance to Muhesa is reduced by about four miles. It is hoped that the last has now been heard of the inaccessibility of Amani.

The improvement of the laboratory and field equipment of the Station is a steady and continuous process in which the local workshops take an indispensable part. Provision has been made during the year for the supply of direct electric current and of distilled water in adequate quantities. The wires of the electrical supply have all been transferred to metal standards.

An event of first class importance is the receipt of notification that capital grants have been made from the Colonial Development Fund for the purpose of providing further facilities for the study

of virus diseases of plants (£1,200), and for the equipment of a central plant quarantine station to meet the needs of the East African Dependencies generally (£3,500). The projects for the establishment in Tanganyika Territory of special experiment stations for sisal and coffee, in which this Station is deeply interested, have made progress during the year. In June, 1931, at Tanga, a conference of the Tanganyika Sisal Growers' Association was held at which the Kenya Association was represented by its Secretary, the Kenya Department of Agriculture by the Deputy Director, the Tanganyika Department by the Director and local officers, and Amani by the Director and the Geneticist. The need for an experiment station was fully conceded, but the question of sites and ways and means was left for enquiry and further negotiations. Possible sites on the Tanga plain have since been examined, but further progress has been impeded by the state of depression in the industry.

On the invitation of the Director of Agriculture a proposed site for a coffee experiment station at Moshi has been inspected by the Director and other officers of the Station. It is understood that this project will shortly be realized.

Although the main purpose of these stations will be the provision of agronomic information urgently required in the advisory work of the Department of Agriculture, they will also provide facilities which are indispensably required for the fundamental research work of this Station.

The financial pressure due to the accumulation of increments on salaries has been somewhat relieved by the effects of two measures adopted by the Tanganyika Government to meet the results of economic depression. Travelling allowances have been suspended except for the bare cost of hotel accommodation when this is necessary, and a graduated levy has been imposed on salaries, the proceeds of which are returned to the Station in consideration of its inter-territorial standing. The first-named measure, in particular, imposes a somewhat serious hardship on officers who are required to travel widely.

The changes made in the management of the Kwamkoro Estate have resulted in the production, for the first time, of a small profit. Definite progress has been made through the more intensive cultivation of selected areas. Considerable and increasing use is made of the estate for experimental purposes.

In view of the need for the regeneration of the East Usambara plantations generally, much interest attaches to the trials which are being made of *Coffea arabica* grafted by various methods on to *robusta* stocks, as well as to the development of improved strains of *robusta* itself, which thrives in the district. The latter is also an important economic crop, produced mainly by natives, in the Bukoba Province of Tanganyika and in Uganda.

Forty bales of Cinchona bark, representing all the kinds grown at Amani, were prepared and shipped to London. The qualities were reported to be quite satisfactory, and normal prices were obtained.

The progress reports of the scientific officers are sufficiently explicit to require no comment. Satisfactory progress, fully commensurate with the working capacity of the Station, has been made in every section. Results of immediate economic importance, although incidental to the main lines of research, have been achieved in the investigation of tea disease in Nyasaland and are expected with considerable confidence in matters concerning the sisal and coffee industries.

The publication of results in the form of papers contributed to scientific journals is proceeding at an increasing rate, but their appearance is usually somewhat delayed owing to the amount of competition for available space.

The Station has continued to perform a useful function in distributing seeds and other propagating material from the collection of economic plants of which it has custody. Interesting additions to this collection are frequently made by gift and exchange.

The Director has continued to serve as Chairman of the Standing Committee on Soil Erosion in Tanganyika Territory. Study of the predisposing causes of soil erosion and investigation of the means available for its prevention and arrest have a wide interest, as the conditions obtaining in parts of Tanganyika Territory also occur in the neighbouring countries. Agricultural practices connected with the shifting cultivation of the natives and the failure in European-owned plantations to realize the imperative necessity, under some conditions, of measures for the conservation of cultivated soils are responsible for much deterioration, but they can be and are being gradually counteracted through the educational efforts of agricultural officers. Of more serious importance, on account of the difficulty of the administrative problems involved, is the progressive destruction of wide areas due to the rapid increase of the flocks and herds of the pastoral tribes of the Bantu. The Masai, owing to their nomadic habit, are little, if at all, concerned.

To the extent to which the rough census figures are reliable they show that the numbers of native-owned cattle have increased enormously since the war. The grazing areas, which are mostly semi-arid, are hemmed in by barriers of tsetse-infested country and over-stocking grows more and more severe. Its effect is to lay open the soil to sheet erosion which removes the soil from the slopes and covers the valley floors with deposits mostly of sterile sand. Frequently also the unrestrained flow of storm water dissects the countryside with a hopeless network of deep gullies.

The fundamental trouble is the lack of an economic basis for the keeping of cattle. Apart from sale of the hides provided by death from natural causes and the very small proportion of animals sold for meat, a cattle industry cannot be said to exist and there is no check to the annual increase save that imposed by disease and starvation. In the interests of the country as a whole and particularly in the interests of their owners, whose lands are destined to be reduced to desert in a measure of time which can be set, in the most advanced instances, at not more than twenty years, cattle must under present circumstances be regarded as pests. In comparison the damage done by locusts, to which so much attention is at present directed, is transient and unimportant.

The imposition of artificial restrictions presents great difficulties; the extension of pasturage by driving back the tsetse, unless related to a general policy of restriction, can provide only temporary relief and will end in opening up fresh areas to devastation. The most hopeful line to take is the provision of a sufficient market to dispose of the natural increase, and in this connexion the experiment which is being made in the local preparation of meat products, especially meat and bone manure, must be regarded with deep interest. Its success on a large scale would convert the millions of cattle in the country from a liability to a valuable asset.

PUBLICATIONS.

The following papers have up to the present been contributed to scientific journals by members of the staff of the Research Station :—

*(1) Records of Butterfly Migration in East Africa. C. B. Williams, *Journ. East Afri. Ug. Nat. Hist. Soc.*, No. 35, 1929.

*(2) Collected Records Relating to Insect Migration : Second Series. C. B. Williams, *Transactions of the Entomological Society of London*, 78, Part I, 1930.

(3) Locust-hoppers and Birds in East Africa. R. E. Moreau, *Bulletin of Entomological Research*, 21, Part II, 1930.

(4) The Bird-population of a Settled Valley in the West Usambaras, Tanganyika Territory. R. E. and W. M. Moreau, *Journal of Ecology*, 19, No. 1, 1931.

(5) The Filtration of the Virus of Streak Disease of Maize. H. H. Storey, *Annals of Applied Biology*, 19, No. 1, 1932.

(6) The Estimation of Carbon in Plant Tissues. R. R. Worsley and F. J. Nutman, *Annals of Botany*, 45, No. 180, 1931.

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* Preparatory to Mr. Williams' book *The Migration of Butterflies* published in the Biological Monographs Series.

In addition the undermentioned papers have been completed and are now in the hands of editors awaiting publication :—

(7) A Bark Disease of Coffee in East Africa. H. H. Storey.

(8) Vegetation of Mpwapwa, Tanganyika Territory. P. J. Greenway.

(9) The Bearing of Insect Vectors on the Differentiation and Classification of Plant Viruses. H. H. Storey.

VISITORS.

Oversea visitors to the Station during the year include Mr. Ifor L. Evans, St. John's College, Cambridge, and Dr. O. Hartleb, Hamburg.

Official visitors include Mr. J. McDonald, Senior Mycologist, Department of Agriculture, Kenya; Capt. H. B. Watson, Juba, Sudan; Mr. D. K. S. Grant, Conservator of Forests, Mr. A. J. Wakefield, Senior Agricultural Officer, Messrs. F. W. Thomas and G. W. Lock, District Agricultural Officers, Messrs. W. H. Potts, Entomologist and G. W. St. Clair-Thompson, Botanist, Tsetse Research, Dr. C. L. Ievers, S.M.O., and Dr. W. J. Aitken, M.O.H., Tanganyika Territory.

A large number of visitors representing various East African agricultural interests were also received.

W. NOWELL,
Director.

REPORT OF THE PLANT PATHOLOGIST.

RESEARCH.

The Conference of Directors of Agriculture held at Amani in 1931 accepted a programme for the Plant Pathology Section of the Station, consisting of :—(*a*) Research into the problems of virus diseases, and (*b*) consultative duties and such *ad hoc* investigations as may arise therefrom. The aims and progress of work within this programme which it has been possible to undertake with the present staff may be elaborated as follows :—

(a) *Virus Disease Research.*

(1) Studies of a fundamental nature into the manner of action of the virus within the plant and the insect-vector, aiming ultimately at a clearer understanding of the nature of the virus.

(2) Investigations of various virus diseases of local importance, aiming at the discovery of the more simple features of the diseases, such as manner of transmission, host-range, etc.

(b) *Ad hoc Investigations.*

These problems are dealt with as they arise, but during the past year the following have received attention :—

(1) A bark disease of coffee in Tanganyika,

(2) The yellows disease of tea in Nyasaland.

(*a*) Virus Disease Investigations.

1.—*Vector-insect and Virus.*

Of the many possible lines of investigation which may be expected to lead to a clearer understanding of the nature of virus diseases of plants I have selected for intensive study during the past years the relation between the vector-insect and the virus. Many viruses may be readily transmitted from plant to plant by simple mechanical inoculation, and some only with difficulty. Others have resisted all attempts at mechanical transfer. Streak disease of maize belongs to the latter class. The results of nearly ten years' trials, in which many different methods of mechanical inoculation have been employed, have been consistently negative. On the other hand, the vector *Cicadulina mbila* Naude transmits the virus readily. Hitherto this species has been the only known vector, although many other species of insects have been tested.

In recent work I have been able to show that the specialization of the virus to its vector is even narrower than was previously thought. The ability to transmit within the species *Cicadulina mbila* is controlled by an hereditary factor. I have bred pure races, of which all members were capable, under the appropriate conditions, of transmitting the virus. These active races have now bred true for this factor through many generations. On the other hand, inactive races which are unable to transmit the virus under a wide variation of conditions have also been bred. Breeding from crosses between the two races has shown that the power of transmission is inherited as a simple Mendelian factor. The ability to transmit is dominant to the inability to transmit, and this factor is linked with sex. A brief account of this work has been published (*Nature*, CXXVII, p. 928) and a full account is now prepared for publication.

During the course of this year I have found a new vector-species in the closely related leafhopper *Cicadulina zeae* China. Breeding of pure races of this species has been started. I have obtained a race of Inactive hoppers, but as yet the attempts to obtain pure Active races have been unsuccessful owing to the falling-off in fertility of in-bred lines.

The Active and Inactive races of *C. mbila* are indistinguishable morphologically. I have been unable to discover any feature in their structure or habits to account for their differing behaviour

towards the streak virus. It is likely that the difference lies in some internal reaction in the insect. The nature of this reaction is now under study. For one line of attack on this problem I have developed a new technique for the study of the virus in the leafhopper. The employment of this technique has afforded some remarkable results, which are being followed up.

The ability of *C. mbila* to take up the virus from liquids by feeding through a thin membrane was noted in my last report. An account of experiments in the filtration of the virus of streak disease has been published (*Ann. Appl. Biol.* XIX, pp. 1-5). The virus was there shown to be present in bacteriologically sterile filtrates. This technique is being employed in the study of other features of the transmission process.

A disease of maize occurring in the Amani district which closely resembles streak disease in the majority of its features, has now been shown to be transmitted by the Fulgorid leafhopper *Peregrinus maidis*. This species cannot transmit the common streak virus, nor can *Cicadulina mbila* transmit the new virus. It is possible that the new virus is identical with that investigated by Stahl in Cuba (*Trop. Plant Res. Foundn. Bull.* 7, 12 pp.).

I expect therefore to be in the position to carry out comparative studies between two races of each of two species of vectors of the maize virus, and between these and the vector (belonging to a different group of insects) of a closely similar but distinct disease.

In the transmission of rosette disease of groundnuts by *Aphis leguminosae* certain obscure features have been encountered. Studies of this problem are in progress.

I contributed to the Duexième Congrès International de Pathologie Comparée, held in Paris in October, 1931, a paper entitled " The Bearing of Insect-Vectors on the Differentiation and Classification of Plant Viruses ".

2.—*Leaf-curl of Tobacco.*

Considerable time has been occupied in work upon the tobacco disease to which reference has been made in previous reports. The disease is characterized by curling of the leaves and emanations from the veins on the lower surface. Early experiments appeared to exclude the possibility of this disease being of virus origin. I have now, however, shown that it is transmissible by grafting and by an insect-vector, a White Fly, *Bemisia sp.*, and is therefore probably caused by a virus. In its symptom characters and in its vector this disease resembles the leaf-curl disease of cotton in the Sudan and West Africa. Experiments, however, carried out in co-operation with the Entomologist of the Station failed to show transmission of the tobacco disease to cotton. A common weed, *Vernonia* sp., appears to contract the tobacco disease. A short report of these results has been published (*Nature*, CXXVIII, pp. 187-188).

This disease appears to be widely spread through Africa, and recently severe outbreaks have caused alarm. The loss of an entire crop in Zanzibar originally led to the investigations at Amani. Dr. E. S. Moore of the Division of Plant Industry, Department of Agriculture, Union of South Africa, agrees that this disease occurs in the tobacco of the Transvaal. In a short visit to Southern Rhodesia, made at the request of the Minister for Agriculture, I was able to identify as this disease an affection which had caused some concern to the Department of Agriculture of Southern Rhodesia. An experiment, carried out in collaboration with Mr. J. C. Hopkins, Mycologist in that Department, confirmed the ability of a local species of White Fly to transmit the virus. The same disease occurs in Nyasaland, where I examined plants at the request of the Director of Agriculture. In a recent letter, M. J. Ghesquière informs me that he has transmitted a similar tobacco disease in the Belgian Congo with White Flies.

A disease of tobacco in Java of closely similar manifestation, known as "kroepoek", has recently been investigated by Dr. Thung, who has published an account of his work (*Meded. Proefst. Vorstenlandsche Tabak*, No. 72). He also has transmitted the disease with White Fly.

3.—*Groundnut Rosette Disease.*

At the request of the Director of Agriculture, Uganda, I visited the Eastern Province of Uganda in July and August, 1931. I was able to confirm the identity of the rosette disease in Uganda with that which I had studied in South Africa. Experiments proved that *Aphis leguminosae* might act as the vector of the Uganda disease. The most important outcome of my tour of the groundnut-growing region was the realization that the existing native methods of cultivation appear to give a large measure of control of rosette disease. The important features appear to be a heavy broadcast sowing-rate and a grass-mulching of the soil after sowing. I suggest that the close cover over the soil resulting from these procedures affords conditions which are unfavourable to the aphid-vector and so lessens the spread of the virus in the fields. Whatever be the explanation, however, there was clear evidence that rosette infestations were less severe in closely-planted native plots than in widely-spaced plantings. The experiments of the Department of Agriculture, the details of which I have received from the Director, in like manner showed significant differences in favour of close planting. Experiments have been carried out at Amani in the transmission of the rosette virus to a number of leguminous plants, but no success has been obtained.

4.—*Sugar-cane Mosaic.*

A mosaic disease which has been found in one variety of cane grown in East Africa has been under study, with a view to deciding its relation to the common sugar-cane mosaic.

(*b*) Ad hoc Investigations.

1.—*Bark Disease of Coffee in Tanganyika.*

The studies of this disease have been concluded and an account has appeared in the *Annals of Applied Biology*, XIX, pp. 173-184.

2.—*Yellows Disease of Tea in Nyasaland.*

The investigation of this disease which has been prosecuted in collaboration with Mr. R. Leach, Mycologist in the Department of Agriculture, Nyasaland, has been brought to a successful outcome. We have shown that the disease is caused by a deficit of sulphur in the tea bush and may be cured by the addition to the soil of sulphur in some form. The experiments laid out by Mr. Leach in the tea gardens of Mlanje have convincingly demonstrated that a complete cure of bushes which have reached an advanced stage of the disease may be rapidly achieved by treating the soil with sulphates of ammonium, potassium, magnesium, or sodium. The early results of recent experiments indicate that the element surphur will be an equally effective dressing. Meanwhile water-culture experiments at Amani have demonstrated that all the symptoms of yellows disease may be produced in tea seedlings which have received all nutrients except sulphur. In several other ways we have confirmed our hypothesis for the causation of this disease.

The disease has been described by Dr. Butler as " unquestionably one of the most serious diseases to which the tea bush is liable." The discovery of a simple, cheap, and effective cure is likely to have a large influence on tea growing in Nyasaland. Already the efficacy of the treatment which we have recommended has been demonstrated in an unmistakeable manner by certain planters in their own gardens.

I visited Nyasaland in February, 1932, for consultation with Mr. Leach, and a paper describing our work was read to the Nyasaland Tea Research Association. A full account of our experiments is now in preparation for publication.

CONSULTATIVE VISITS.

During the course of the year the following visits were paid to East African territories. Reference has been made earlier in this report to certain of these visits :—

(1) To the Eastern Province of Uganda, to advise the Department of Agriculture on investigations to be undertaken for the control of groundnut rosette.

(2) To the Sotik District of Kenya, for the discussion with members of the Department of Agriculture of measures for the control of coffee berry disease.

(3) To Ramisi Sugar Estate, Kenya, with the Mycologist, Department of Agriculture, Kenya, for observations on sugar-cane diseases.

(4) To Southern Rhodesia, to advise upon the control of leaf-curl of tobacco.

(5) To Nyasaland, for discussion with officers of the Department of the yellows disease of tea and leaf-curl of tobacco.

GENERAL.

During the year under consideration my single experimental greenhouse has always been greatly congested, and the lack of space has forced me to hold over several lines of investigation. The grant of money for the construction of two more houses from the Colonial Development Fund is most opportune, and the new houses will greatly facilitate my work.

I have continued to receive valuable assistance from Mr. R. F. W. Nichols, my Laboratory Assistant.

H. H. Storey,
Plant Pathologist.

REPORT OF THE ENTOMOLOGIST.

I arrived at Amani on 13th August, 1931. The following preliminary tours were undertaken, in order to gain some acquaintance with local conditions and discuss problems with the staffs of the Departments of Agriculture of the various territories :—

September, 1931 : Tanganyika—Morogoro and Lushoto.

October-November, 1931 : Tanganyika—Moshi and Arusha Districts ; Kenya—Kiambu, Ruiru, Thika, and Nyeri Districts ; Uganda—Kampala, Masaka, Elgon, and Serere Districts.

In addition to the above tours, ten days were spent in Zanzibar during March, 1932, for the purpose of ascertaining the economic status of a Scarabaeid (" Cockchafer ") beetle, the larvae of which had been alleged to be eating the roots of clove trees and causing widespread die-back. The conclusions arrived at have formed the subject of a report to the Director.

At the Conference of Directors of Agriculture held at Amani in February, 1931, it was agreed that the work of the Entomologist should fall under one or more of the following heads :—

(1) Ecological aspects of entomological problems.
(2) The resistance of plants to insect attacks.
(3) Insect nutrition.

More particularly is the first of these subjects in every way suitable to be included in the programme of an institution devoted to long-range research. In every branch of economic entomology it is becoming increasingly recognized that an understanding of the environment of an insect pest and of the reactions of the insect in relation to its environment is an essential requisite upon which to base

any control measures that are to be more than merely temporary and palliative. Consequently it has been decided, with the approval of the Director of Amani and the Directors of Agriculture of the contributing territories, to concentrate on ecological problems.

Ecology is a wide subject, which does not merely consist, as has been alleged, of " saying what everyone knows in language which no one understands," and it is clearly beyond the capacity of one individual to study the whole field of ecology of even one crop in one limited area.

It is therefore proposed that an investigation into the relation of climate to insect pests, beginning with the insect pests of coffee, should form the main item in the Entomologist's programme.

There are two methods by which such an investigation could be tackled. The first, and doubtless the more accurate, would be by means of climate-simulation experiments. Excellent suggestions for the conduct of such research are given in a recent Textbook of Ecology (Shelford, 1929). The chapter concludes however with the words " A small plant built on the principles discussed probably can be built for $300,000 or less." This being a sum about one hundred times greater than that available for all the Amani laboratories during the past year, the second and more practical method will be adopted.

This will consist in ascertaining as accurately as possible the climatic conditions in the exact habitats of the insects associated with the coffee plant. Particular attention will be paid to those climatic factors which are capable of modification by certain agricultural practices, and field observations and experiments will be made to determine the influence of such modification on the more important economic insects. It is hoped that it may be possible to find some correlation between eco-climatic conditions and conditions as recorded by standard meteorological methods.

Whether anything approaching a complete study of the eco-climates of a coffee plantation can be accomplished single-handed remains to be seen; the importance of the subject is, however, great, but the work previously attempted on it (so far as I am aware, and at any rate in East Africa) is practically nil; so that any information obtained, even if somewhat fragmentary, should be of practical value to the coffee planter.

There has been some unavoidable delay in obtaining or constructing the necessary apparatus and equipment, but it is hoped to start observations on a coffee plantation in the Kiambu District of Kenya in May, 1932.

Preliminary tests, in conjunction with the Biochemist, with extracts of various locally-grown plants with insecticidal properties have been somewhat handicapped by the lack of suitable insects in

quantities sufficient to experiment with. It will probably be necessary to breed up artificially large numbers of some insect such as *Antestia*.

Classification of the entomological literature in the Library has occupied a considerable amount of time and is approaching completion.

T. W. KIRKPATRICK,
Entomologist.

REPORT OF THE SOIL CHEMIST.

The period under review is again less than a full year, owing to my absence on leave in England during the 6½ months from April to October.

Last year, I reported progress under a list of headings provided by the programme which had been outlined in the Report for 1929-30. The same headings are used again, but meanwhile the list has lengthened. As re-defined by the Conference of February, 1931, the programme now lays emphasis on fertility and amelioration studies in regard to crop-production (Third Annual Report*, p. 6). This emphasis had been avoided in the earlier draft, the intention being to " study soils as they are, before facing questions involved in their use or improvement " (Second Annual Report†, p. 16). The principle now adopted explains the introduction of the headings *Nitrogen-changes*, *Manuring*, and *Irrigation Problems*, in the progress report below.

1.—*General Survey and Classification.*

In 1930, the part which Amani should play in soil survey work in the six territories was arranged in outline by correspondence with the several Governments. During my leave in England the outcome of the discussion was communicated to the Imperial Bureau of Soil Science (the co-ordinating authority for various current projects of Empire soil mapping), and the scheme is now nominally operating. To date, however, I can report further progress for Tanganyika only, as material has not yet begun to come in under the scheme from the other territories. Details are to be discussed personally at a meeting of soil chemists which has been arranged for May, 1932. It is hoped that at this meeting also a provisional procedure in classifying and naming soils will be evolved for uniform use in East Africa.

In addition to the localities list in the last Report, the following areas in Tanganyika are now represented in the sample collection and by field notes :—Bukoba, Dodoma, Kilwa, Morogoro, Shinyanga, and Tukuyu. Grateful acknowledgement is made to

* Colonial No. 69. † Colonial No. 51.

the Agricultural and other officers who have contributed. Most of this new material has not been more than very cursorily examined. It appears that the limiting factor in the reconnaissance soil survey in Tanganyika (at least of the economic soils) will not at present be the amount of assistance available from interested lay observers, nor its quality, but the laboratory time required to do justice to their collections. The survey must lag and possibly the interest of the contributors must wane, unless either Tanganyika or Amani is enabled to provide the laboratory staff to deal more quickly with the samples that are being accumulated.

I spent the month of March in the field in the Meru and Kilimanjaro area. The journey took me to most of the settled parts around the two mountains and, though on the basis of this introduction I should in no sense be justified in attempting to demarcate soil boundaries or in supposing that I have all the main types noted, I now have material enough for the study of these soils in some detail, and further sampling has been arranged for. The co-operation of Messrs. Wakefield, Sturdy, Sanders, and Harvey, of the Department of Agriculture at Moshi and Arusha, has been wholehearted and most helpful, and this and their personal hospitality is here acknowledged. Further reference is made to work on Kilimanjaro and Meru soils in the next section, where a discussion of classification questions will also be found.

A feature which it is becoming necessary to add to the sample-collection (which now numbers about 1,100 samples) is the display of representative soil profiles in permanent form, both for purposes of current comparison as study and classification proceeds and for inspection by technically-interested visitors. At present there is no accommodation for this, and I hope that it may be found possible to provide it before long.

2.—*Special Studies of the Soil Groups.*

For the " red " soils of the Usambara rain forest, grasslands, and foothills, for the complex of soils on the volcanic rocks of Kilimanjaro and Meru, and for certain black-soil phases in both areas, there is now to hand a considerable body of analytical data concerning particle-sizes, organic carbon, total nitrogen, certain moisture-constants, and reaction. A good many more samples remain however to be dealt with before the material to hand has been worked up even in this limited sense; and I also await the results of other series of determinations essential to soil characterization (e.g., ultimate analyses of the clays) before publishing.

In the meantime the lines on which classification of these soils will probably develop are becoming clearer, and may usefully be discussed. There is much advocacy nowadays of the American system of describing soils under " series " and " type " names,

sometimes misleadingly spoken of as in itself a system of classification. The *series* is named after some one locality in which it is found, and defined by all the characteristics of site and soil-profile with the exception of texture. Texture is then used to define subdivisions of the series which are called *types*. The system is not so much unobjectionable as unavoidable beyond a certain stage in soil survey, for names must be coined somehow and cannot in any case be made satisfactorily descriptive. Thus we may come to speak in the Usambara of a Kwamkoro series, with its constituent types, the Kwamkoro clay-loam and the Kwamkoro sandy-loam. Either of these might then come to be mapped, still under the same name, in the Uluguru Mountains or in Kenya. There need be no difficulty about setting up a central directory of such series names and their connotations for reference and for the avoidance of synonyms, with supplements to be circulated to all soil workers as the survey progresses. So much may be accepted at once for the American system. Something of the kind will be definitely needed as soon as it becomes a question of providing detailed guidance in land-utilization by means of a soil survey on a close scale, and the names can be used in the meantime as a convenient means of speaking of particular soils.

In its standardized form, however, the system leaves us with the *series* as the largest soil unit. And to set out to map by series in East Africa at present would be impracticable, for no two-dimensional *survey* in the sense used by the American surveyors is possible, but only a *sampling*, with at present quite a large sampling-error. There will be many series that we have not happened to encounter, and therefore the smallest soil unit to be used must be sufficiently generalized to override our imperfections of detail. The problem of framing the bigger units is thus the only classification problem that at present matters much; we can go into nice discriminations between series later on. And the bigger-unit problem has by no means reached any standardized solution, much worked-upon though it has been, in America as elsewhere.

The groupings of ordinary non-technical usage, four or five of which (namely, colour, rainfall, vegetation, topography, and broadly-stated geology) were employed in one breath in the opening lines of this section, are of course useful at times, but for critical purposes the choice lies between a soil-climatic and a lithological interpretation of the causes of observed soil-profile characters, for providing the key to the new groups. Coming now to the particular soils under discussion, it appears that neither the one nor the other scale of reference works well with *all* the soils as a first test to apply in classifying them. Climatic groups should be easily recognizable in this area, where the zones of overhead climate are sharply focussed. Many of the exposures of which I have notes do, in fact, range themselves very well on one side or the other of the

main division between " pedocals " and " pedalfers " (Marbut's terminology, 1927). The pedocals generally lie off the mountains and off the European plantations, and the limitations of my travelling have not yet given me opportunities of sorting them out. Amongst the pedalfers, the effects of steady through-leaching, of intermittent through-leaching, of leaching to a water-table, and possibly of temperature (altitude) differences superimposed on these can be distinguished. Parent-rock characters come in as modifying influences which provide sub-divisions of the groups. Thus the gneiss of the Usambara varies; there are granulites and pegmatite veins and basic intrusions, rocks rich or poor in iron; the Kilimanjaro lavas are again different; but these rock-differences do not always make the soils so different within a climatic group, as the climatic groups are different from each other. So far the view of the dominance of climatic effects holds good; but on the other hand the volcanic ejecta of Meru particularly, but also of Kilimanjaro, vary to wide extremes in lithological character, so that in the so-called " ash " soils and some of the weathered lavas mechanical and chemical factors seem to rank not merely as influences modifying the effects of climate but as the dominant causes of soil properties and as persisting in that role. These soils are endodynamomorphic though not necessarily immature, a distinction unfortunately not always preserved when using the two words. And to such soils it becomes unhelpful to apply climatic effects as the significant classifying criteria, even when they are on examination detectable in the soil profile. We should here classify on lithology and sub-classify by climate when the evidence warrants it.

Two examples are cited below in support of this view, which will seem to some a reactionary one. (1) The black-grey powdery soils overlying a lava rock-pan at no great depth, which occur at three observed points (Eastern Usa, Sanya Juu, and Engare Nanyuki) on the east side of Meru, and probably form a continuous belt there, are a clearly recognizable unit, notwithstanding that they lie astride a humid belt joining the two mountains and extend into semi-arid country to the north and to the south. (2) The accident that the country-rock at certain points is more than usually calcareous and weathers into a limestone brings about very characteristic black soils here and there, which have almost no points in common with the neighbouring non-calcareous soils having the same topographical lie and overhead climate. To say that both kinds belong to a pedocalic zonal type may be true, but that assertion should not receive the main emphasis, seeing that their essential difference remains unstated until the geological factor dominating it is brought forward. This example is quoted from near Himo, and at Engare Nairobi, and again possibly at Tengeru.

Broadly speaking, it seems that the Meru soils will have to be regarded as endodynamomorphic, i.e., governed throughout in their course of development by intrinsic parent-rock properties, while

those of most parts of Kilimanjaro and of Usambara are more clearly impressed by climate. There are, of course, also immature soils in the ordinary sense in all three areas.

It may be noted in passing (as it was but noted in passing in the field) that a considerable extent of a pedocalic soil, chestnut-coloured,* and possibly akin to the South Russian soil so designated, may have to be mapped on the plains south-west of Meru towards the older volcano Mondul. A speculative identification of one of the black soils with *tchernosem* is not yet convincing.

3.—*Manuring.*

In this section is reported, by arrangement with the Geneticist, the laying-down of a manurial experiment on coffee which he initiated and has been mainly responsible for, but in which I at a later stage co-operated. His problem was originally to obtain guidance for fertilizing the plots of coffee-varieties that are established but in some cases are making disappointing progress, at Ohehe, Kwamkoro. The results, however, if of value in this connexion, should also be of general application under similar conditions. A block of old *arabica* coffee of the pre-war plantings, part of it level, part on moderate slope, and part on steep slope, was selected, being the most suitable the estate afforded. The block is sub-divided into 48 plots (eight rows of six), equal in area but containing numbers of trees varying from 34 to 12, owing to inequalities of stand. The trees are spaced, where regular, 8 feet by 8 feet or 681 to the acre. The 1931 harvest was weighed for each plot, to gain an idea of uniformity. This was not very encouraging, as the weight of cherry per tree for individual plots varied from 0.06 lb. to 3.12 lb. per tree. There is however an eightfold replication of six treatments, so that over several years, and if yields are considered always as per tree and not per unit area, any result large enough to be of practical importance should be distinguishable. The present level of yield is so low that if the use of fertilizers is to be economic relatively large percentage increases must be looked for.

Within each row the following six treatments are arranged at random :—

A. 1N + 1P + 1K.
B. 1N + $\frac{1}{2}$P + 1K.
C. 1N + 2P + 1K.
D. 1N + 1P + 2K.
E. 2N + 1P + 1K.
F. Nil.

where 1N = 30 lb. nitrogen as 143 lb. sulphate of ammonia,
1P = 16 lb. phosphoric oxide as 40 lb. double superphosphate,
1K = 40 lb. potash as 84 lb. sulphate of potash,

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* Castanea, not Aesculus.

the dressings being annually at these rates per acre, applied proportionately per tree in half-yearly quantities in November and April. The principle of these dressings is to accept guidance from the composition of coffee-cherry, but to vary phosphate by two stages and nitrogen and potash by one stage each.

4.—*Nitrogen-changes.*

A simply-planned series of nitrification experiments has been started, mainly with a view to gathering experience for more comprehensive ones later on if the laboratory time required proves not to be more than can be afforded with the present staff. The questions asked of the experiment at present are at what rate and in what direction does the nitrogen-status of a typical Kwamkoro surface soil change, when maintained at an arbitrarily fixed moisture-content and a temperature ranging from about 23° to 27°C. daily, with

(*a*) no addition,

(*b*) addition of powdered Crotalaria leafage having a dry-matter nitrogen content of 4.5 per cent.,

(*c*) addition of powdered forest leaf-fall having 1.5 per cent. nitrogen,

(*d*) addition of sulphate of ammonia.

The course of the changes is being followed by fortnightly withdrawals of duplicate units of the experiment and their analysis for nitrate, ammonia, and total nitrogen.

5.—*Erosion.*

I have nothing to report under this head except that some samples of badly-eroded soils formerly collected have been partly examined, with results of little interest because the samples are too few. I have not yet visited the areas in Tanganyika where the main problems in large-scale erosion arise.

In the Northern Province I saw with much interest the progress that is being made under the Department of Agriculture, in combating less spectacular forms of erosion on both native and European cultivations by methods of contour-ditching, hedging, cover-cropping, and substitution of forking for hoeing. The African cultivator in permanent possession of his own garden, at any rate when he has the interest of a cash crop to stimulate him, is evidently teachable enough in these matters when the right teaching is brought to bear.

6.—*Irrigation Problems.*

Officers of the Department of Agriculture in Tanganyika have recently directed the attention of planters to possible dangers latent in some of their irrigation practices, more particularly in the Arusha District. Salt crusts, or appearances resembling them, have been

observed at the surface of soils frequently irrigated without provision for drainage, and as some of the rocks thereabouts are known to be rich in soda minerals and some of the streams are known to be alkaline, the risk of "alkali" troubles developing cannot be ignored. There are in fact definite instances where the wilting and death of coffee are attributed to salt-concentrations about the roots. Several samples of surface efflorescences from the suspect area have been examined at Amani, not always with the results anticipated from their appearance, but in general confirming their nature as symptoms of faulty irrigation practice. It will be necessary to pay attention to the amount and distribution of soluble salts in the profile in these Arusha soils. In the same connexion a number of water-samples have been received and examined. Fairly high salt-contents and an alkaline reaction due to sodium carbonate have been found to be usual features of the streams originating on Mount Meru (many of them used for estate irrigation) but with considerable local and periodical variation. The results are of such interest that this work is being continued, and Mr. Sturdy, Agricultural Officer at Arusha, is collecting regular periodical samples from the more important waters of Meru. To date, 62 water-samples have been analysed, representing the following streams :—Engare Narok, Engare Olmotonyi, Selian, Burka, Themi, Malala, and some other springs and irrigation furrows. The results will, it is hoped, be published during the coming year. The analytical work on this subject has been entirely in Mr. Calton's hands.

7.—*Manganiferous Soils.*

Except for a period of a few weeks during my leave in England, when by the courtesy of Professor N. M. Comber and the authorities of the University of Leeds I was able to work in the laboratories of the Department of Agriculture there on East African material bearing on this question, I have been unable to devote systematic attention to manganese in soils. Its widespread occurrence in notable though never large quantities continues to come to notice, however, and a few determinations of the order of magnitude of the amounts involved have been made during the year at Amani. I do not yet know if any agricultural significance is to be attached to it. The work at Leeds was incomplete and remains to be taken up again at Amani later.

8.—*Sulphur in Soils.*

In connexion with the Plant Pathologist's work on the yellows disease of tea, some determinations of total and water-soluble sulphur were made on the soils affected. These have served only to show that neither figure reflects the sulphur-deficiency to which the tea plant is sensitive, if good and bad soils (in this sense) are compared. It seems more likely that a significant value would be found in the rate at which sulphur becomes soluble by bacterial oxidization of protein or by weathering of soil minerals rather

than in the sulphur-status at any time considered statically. Sulphur studies from this point of view may later on be combined with the further soil-nitrogen experiments that are intended. The analytical work on tea-plant material, referred to in this connexion in last year's Report, was taken over by the Biochemist.

9.—*Miscellaneous.*

During my journey to England in February-March, 1931, I was able to call upon and discuss soil matters with the Agricultural Chemist at Salisbury, Southern Rhodesia (Mr. A. D. Husband) and officers of the Union Department of Agriculture, Division of Chemistry, at Pretoria (Dr. Sinclair, Dr. van Zyl, Dr. van der Merwe) and at Cape Town (Mr. B. de C. Marchand). I wish to express appreciation of these gentlemen's courtesy and hospitality in demonstrating their work to me. Correspondence which has ensued will assist materially in bringing East African soil work into its proper relation with work in progress in the Union and in Rhodesia.

Mr. M. H. French of the Tanganyika Veterinary Department worked in this laboratory on the composition of grasses during three months in 1931. This opportunity of affording short-term facilities to another worker on a matter of much relevance to soil science was welcomed, though it occurred in my absence, and I should be glad if such occasions could become frequent.

The preparation of a subject-index of the literature of soil science available in the Library here has occupied some weeks in the aggregate, during the year.

A number of lime analyses have been carried out to assist Mr. Ritchie, Entomologist, Tanganyika, in his search for a lime suitable for preparing insecticides on the plantations.

Mr. W. E. Calton was in charge of the laboratory during my absence on leave. He also undertook a series of periodical measurements on coffee-plants for the Physiologist during this officer's leave at the same time. He also does the Station's meteorological observing, under the Geneticist's charge of that work. I desire to express appreciation of the amount and quality of his analytical work during the year in spite of the two latter distractions.

G. Milne,
Soil Chemist.

REPORT OF THE BIOCHEMIST.

CARBOHYDRATE-NITROGEN RATIO IN COFFEE.

During the year a preliminary paper was published in the *Annals of Botany* (Vol. XLV, October, 1931, p. 693) by the Plant Physiologist and myself on the methods employed here in the estimation of carbon in plant tissues.

Work has continued on the collection and analysis of samples and a large number of results is available. It is evident, however, that many more determinations must be made before we can draw any definite conclusions from the results.

As we expected, it seems clear that " total carbon " cannot replace " carbohydrates " in the determination of the C/N ratio. Since the carbon content of the carbohydrates is less than the carbon content of the remaining portions of the plant, i.e., cellulose, etc., a fall in carbohydrate content causes an increase in total carbon, so that the C/N ration does not even move in the same direction. It does seem, however, that total carbon, which is far simpler and quicker to determine, may replace carbohydrate determinations in any experiment in which carbohydrate changes are being followed over not too long a period. Carbohydrate-nitrogen ratio must always be taken as the basis, but total carbon-nitrogen ratio may often be used to follow the changes taking place.

The C/N ratio appears to be much in the limelight at present and people talk glibly about adjusting the ratio to the correct value and then expecting the tree to be perfect. It must not be forgotten that the C/N ratio is far from being the only important factor in nutrition and also that the actual amount of carbohydrates and nitrogen, as well as the ratio of the two, is important; it is quite possible to have too much or too little of both and yet have what is considered a correct C/N ratio.

The last point is under investigation here in conjunction with the C/N ratio work.

The main lines along which the work is expected to continue in the immediate future are as follows :—

(*a*) Investigation of the C/N ratio and of the actual amounts of carbohydrates and nitrogen in all parts of healthy trees, as an indication of what the normal values should be.

(*b*) Investigation of the above in overbearing trees and trees suffering from die-back. A number of results have already been obtained, but they are not sufficient for making any deductions, since several of them point in opposite directions, probably owing to unavoidable differences in some external factors.

(*c*) Effect on the crop of artificially altering the C/N ratio.

FERMENTATION OF COFFEE.

A number of preliminary small-scale trials have been carried out with a view to preparing parchment coffee without using the process of fermentation. It is not considered that fermentation has any useful purpose other than to soften the mucilage around the parchment and thus render it easily removable by washing. It is a process which takes about 24 hours and if not carried out carefully may result in a discoloured or otherwise partly spoilt product, thus reducing the market value.

A number of substances were tried under varying conditions, and it was eventually found that dilute sulphuric acid would render the parchment ready to wash in about 15 to 20 minutes. After the acid treatment the coffee was washed and dried in the usual way. The acid may be used over and over again.

Three samples were submitted to the Imperial Institute for examination and these were forwarded to coffee brokers for reports on the market value, etc. The samples were (A) ordinary fermented parchment, (B) cleaned by dilute sulphuric acid, and (C) the same as (B), but heated to 75° C. for three hours after drying.

The following extracts are taken from the brokers' report :—

" We find the coffees marked (A) and (B) to be of quite good and useful liquor for our home trade, (B) proving to be just slightly preferable to (A). The coffee marked (C) is of distinctly inferior taste to (A) and (B) . . . . In addition to the foregoing we would mention that (A) and (B) are quite attractive in appearance, both in raw and roast . . . ."

On the strength of the satisfactory results obtained in these trials it has been decided to try the method on a larger scale during the next coffee season at Kwamkoro.

MOISTURE IN PARCHMENT COFFEE.

At the request of the Director of Agriculture for Tanganyika Territory an investigation was carried out with a view to finding a rapid and fairly accurate method for determining the percentage moisture in parchment coffee to replace the old method of biting the berry, the berry being considered sufficiently dry if no indentation can be made by the teeth.

After trying various methods of dropping known weights from a known height I decided that none of these methods was satisfactory and finally recommend the use of a steam oven. The Director of Agriculture decided that a maximum of 12 per cent. moisture could be allowed, and I found that if 100 g. of *arabica* berries were heated in the steam oven for four hours then a loss in weight of over 7.7 g. showed a moisture content exceeding 12 per cent. I also found that a graph could be prepared from which one could easily read off the actual moisture content according to the loss in weight in the oven.

INSECTICIDES.

One of the items on my programme is the use of extracts from poisonous plants as insecticides. This may be divided into two parts—(*a*) the isolation of new insecticides, and (*b*) the use of both new and already known insecticides extracted from local plants for use against local pests.

As regards new substances several plants have been tested, and one shows promise of giving a useful insecticide which, whilst not as efficient as *Derris* and *Tephrosia*, has nevertheless definite insecticidal properties. Other plants are also under examination.

As regards their use against local pests I have made, in conjunction with the Entomologist, a series of tests using extracts from *Derris elliptica* and *Tephrosia vogelii*, both grown in Amani, and from several other local plants, and we found them all to have no effect whatever when sprayed on *Antestia*, one of the chief coffee pests, even when used in very large amounts. They were also without effect on various small beetles, but acted quite efficiently as fish poisons.

In preliminary trials they have all proved useful against various aphides and against Lantana mealy-bug, but these are rather rare in Amani and do not appear to be serious pests anywhere in East Africa.

Experiments are continuing.

A number of chemical analyses have been made for various people, including tea leaf samples for the Plant Pathologist, water-samples from sisal-washing tests, and several substances appertaining to insecticides for the Tanganyika Department of Agriculture.

During the Engineer's absence on leave I have been in charge of the Amani electricity supply.

R. R. Worsley,
Biochemist.

REPORT OF THE PLANT PHYSIOLOGIST.

From April to December the Physiologist was on leave. Research remained at a standstill during these months, with the exception of the shade experiment on Lion Hill. This was in the charge of Mr. W. E. Calton during this period, who carried out the usual routine measurements. Unfortunately, certain data were stolen by natives, thus leaving a regrettable gap in the history of the trees. Considerable damage was done by a storm of more than usual violence, while *Hemileia* has continued to be a source of trouble.

The trees have just borne their first light crop and very considerable defoliation and die-back has taken place in all series except the more heavily shaded ones. Material for chemical work on die-back has thus been afforded. It is as yet too early to be able to decide the ultimate fate of this experiment. Complete data on the growth of young trees in containers under varying shade conditions have been obtained, but the prevailing conditions make it appear doubtful whether the experiment can be carried to its conclusion. It appears improbable that coffee can be carried to maturity in pot culture without considerable expense, owing to the very large amount of suitable soil required and to the difficulty of obtaining suitable containers.

Work on the root system of the coffee plant was started in January, 1932, when a number of trees were excavated and studied at Kwamkoro, where suitable technique was developed. The methods used by other workers have proved unsuitable for coffee plants and for the labour available, and a combination of hand labour and washing by water has been adopted where possible. In March a journey was made to the Moshi-Arusha district where nine trees, representing three districts and five soil types, were studied. This work was discontinued owing to the onset of the rains, but will be resumed as soon as possible.

The results obtained indicate that the root system of the coffee plant is exceedingly plastic, capable of extraordinary modification under varying soil conditions. It also points to the necessity for a study of the deeper layers of the soil, as these appear to be eminently suited for the development of coffee roots and apparently capable of providing no mean proportion of the plant's nutritive requirements. In some cases, even, the deeper soil layers appear to provide a better medium for root growth than the " top soil " layer.

Experimental work on root development, suggested by field observations, has been started.

In collaboration with the Biochemist the collection and analysis of samples for work on C/N ratios and on overbearing have been continued.

Laboratory investigations on the assessment of the total fibre content of a sisal leaf and on the abscission of sisal flowers are in hand.

F. J. Nutman,
Plant Physiologist.

REPORT OF THE PLANT GENETICIST.

GENERAL.

A few weeks were spent on safari in Kenya. Problems of importance in the raising of improved strains of coffee were discussed with the Senior Coffee Officer and several estates of outstanding interest were visited with him. Visits were also paid to sisal estates in the Makuyu, Ruiru, and Naivasha Districts and I have to record my thanks to the Secretary of the East African Sisal Growers' Association for his help during my safari and also for his assistance during the year in obtaining data for a study of variation in the fibre content of sisal. Seed from several plants of sisal, together with bulbils from the same plants, was collected and has been planted in Amani.

PLANT INTRODUCTION.

The following additions to the collection of plant material have been received during the year :—

Coffea canephora, from Department of Agriculture, Ceylon.
C. robusta, from Department of Agriculture, Ceylon.
C. ugandae, from Department of Agriculture, Ceylon.
C. quillou, from Department of Agriculture, Ceylon.
C. hybrid, from Department of Agriculture, Ceylon.
C. arabica var. *Menado*, from Department of Agriculture, Tanganyika.
C. spp. indet. (3), from Department of Agriculture, Madagascar.
C. sp. indet., from Department of Agriculture, Tanganyika. Indigenous sp., Mufindi, T. T.
C. khasiana Hook, Botanic Gardens, Calcutta.
C. eugenioides, Mt. Elgon, Kenya.
C. arabica, Mysore, Limuru, Kenya, seed of three single plants.
C. arabica, Senior Coffee Officer, Kenya.
Thea sinensis, a selection, Series A, Kerogalla Estate, Ceylon, through the Tea Research Institute.
Thea sinensis, Tumbiligalla Estate, Ceylon.
Thea sinensis, Manipuri, Tingamira Estate, Assam.
Thea sinensis, Assam, Tingamira Estate, Assam.
30 spp. and varieties of cover crops, Department of Agriculture, Kenya.
26 spp. and varieties of cover crops, Department of Agriculture, Trinidad.
24 spp. and varieties of cover crops, Indigenous, Department of Agriculture, Tanganyika.
Clitoria cajanifolia, Department of Agriculture, Ceylon.
Tephrosia sp., Uganda.
Agave Franzosinii, Botanic Gardens, Kew.
A. lophantha var. *poselgeri*, Botanic Gardens, Kew.
A. fourcroydes var. *Ixtli*, Botanic Gardens, Kew.
A. decipiens, Botanic Gardens, Kew.
A. Sartorii, Botanic Gardens, Kew.
A. attenuata, Botanic Gardens, Kew.
A. Victoriae-Reginae, Botanic Gardens, Kew.
A. lophantha, Botanic Gardens, Kew.
Furcraea Selloa, Botanic Gardens, Kew.

FIELD WORK.

The land occupied by the work of this section is increasing and further areas at Kwamkoro are gradually being taken over. Plots of all types of plants have made good progress during the year. The plots of sisal seedlings at Amboni and Mnyussi have made fair progress.

PLANT BREEDING.

The first generation of coffee plants raised from seed of selected parents is now coming into bearing and further selections are being made from this material. Yields for the individual trees are being recorded but the chief points being considered in selecting material at present are vigour and health of the trees and uniformity and boldness of the produce.

Plants from the cross between a selected *arabica* parent and a selected *robusta* plant are now growing and further crosses of a similar type have been made. Seed is now maturing on the trees. This interspecific cross, while showing a high percentage of viable seeds, gives many that are very poorly filled. Numbers of seedlings raised from seed obtained by self-pollinating selected plants are now being planted out. Further hybrids between selected *arabica* plants are being made.

Hybrid plants have been raised from seed of a species of *Agave* which seeds freely, and which has many short leaves with a moderate fibre content, crossed with *Agave sisalana*. In addition, this seeding species has been successfully crossed with *Agave americana*, and the development of the hybrids between two such unlike species is awaited with considerable interest.

VEGETATIVE PROPAGATION.

Experiments in the vegetative propagation of coffee have been continued with variable success. Much more work remains to be done before any definite conclusions can be drawn.

QUALITY OF COFFEE.

The investigations on the variability of quality in coffee are being continued and the scope of the work is being widened during the coming year.

COVER CROPS.

Field trials of cover crops and green manure plants are being continued and their use extended in an attempt to build up the fertility of old coffee areas.

L. R. Doughty,
Plant Geneticist.

REPORT OF THE SYSTEMATIC BOTANIST.

The work of this section was interrupted by my absence on leave from April to the end of December.

THE HERBARIUM.

During my absence the herbarium was much improved by some structural alterations when a set of high and inaccessible wall cases were lowered and a working table built up of sections of drawers reconstructed for the storage of carpological specimens, etc.

Contributions.

In the course of the year thirty-one contributions representing a total of 2,309 specimens were received from the following :—

Department of Agriculture, T. T. (officers of)	973	specimens.
Veterinary Department, T. T. (officers of)	81	do.
Royal Botanic Gardens, Kew	360	do.
Bureau of Plant Industry, Washington, U.S.A.	355	do.
Amani Staff	540	do.
Total	2,309	specimens.

Determinations.

A total of 1,154 specimens were determined for :—

Department of Agriculture, T. T., in connexion with botanical surveys and economic plants.

Veterinary Department, T. T., in connexion with indigenous browse and fodder plant investigations and plants suspected of being harmful to stock.

Zanzibar Museum, Zanzibar, in connexion with the botanical survey of Zanzibar and Pemba.

Amani Herbarium, in connexion with the botanical survey of the economic plants established in the Amani Plantations; critical and unnamed *Gramineae* collected by the Germans.

The bulk of this material was determined at the Royal Botanic Gardens, Kew, where by kind permission of the Director of that institute, I spent a considerable portion of my leave working on specimens of difficult members of the family *Pinaceae* and the genus *Eucalyptus* from the botanical survey of the Amani plantations, and also critical and unnamed specimens of *Gramineae*. My thanks are due to Mr. C. E. Hubbard, the Systematic Agrostologist at Kew, for his very kind assistance with the latter. Periodical visits were also paid to the British Museum, to consult their herbarium, and to the Imperial Forestry Institute Herbarium at Oxford to see and name specimens collected in the Zanzibar Protectorate.

Loan of Specimens.

Specimens and types were lent to :—

British Museum ...	91 sheets of *Combretum* spp.	

Exchanges of Botanical Material.

Specimens were exchanged and distributed as follows :—

From, Royal Botanic Gardens, Kew (including an important collection of 247 specimens collected by Mr. B. D. Burtt in the Virunga Mountains)	360 sheets.
Department of Agriculture, T. T. (a collection of Tanganyika Territory plants made by Mr. A. E. Haarer, Agricultural Officer, named by Kew and containing a number of type specimens)	450 sheets.
Bureau of Plant Industry, Washington, U.S.A. (specimens of East African *Gramineae*, collected and named by Dr. A. S. Hitchcock)...	355 sheets.
Total received ...	1,165 sheets.
To Royal Botanic Gardens, Kew (including portions of ten type specimens of *Gramineae* not represented at Kew)	784 sheets.
Department of Agriculture, T. T.	77 sheets.
British Museum, London	4 sheets.
Total distributed ...	865 sheets.

Types.

When determining specimens for various departments twenty type specimens were found and recorded, and the following new species from the Amani Herbarium have been described :—

Kraussia speciosa Bullock in Kew Bull. 1931; 256 (Rubiaceae) T. T. : Kimboza, Mikese-Kisaki Road, 1,500 ft. altitude, *Greenway* 2516, type.

Loranthus acacietorum Bullock, l.c. 271 (Loranthaceae) T. T. : S. W. Pares; Mwembe, 3,000 ft. altitude, *Greenway* 2065, type.

Lagynias pallidiflora Bullock, l.c. 273 (Rubiaceae) T. T. : Sigi, *Zimmermann* 3219, type, and *Zimmermann* 1021.

Tecomaria rupium Bullock, l.c. 274 (Bignoniaceae) T. T. : N. Mpwapwa, 5,000 ft. altitude, *Greenway* 2425, type.

Leucas pododiskos Bullock, l.c. 275 (Labiatae) T. T. : S. Pares; S. Same 2,700 ft. altitude, *Greenway* 2115, type.

Renschia mirabilis Bullock, l.c. 457 (Labiatae) T. T. : Mpwapwa, 3,600 ft. altitude, *Greenway* 2450, type.

With these six new species the total number of type specimens recorded in the Amani Herbarium is now seventy-three.

FIELD WORK.

The collection of specimens and data for the botanical survey of the economic plants in the Amani Plantations has been completed.

P. J. Greenway,
Systematic Botanist.

ORNITHOLOGICAL WORK.

As before, this was mostly carried on outside official hours. Relations with the British Museum authorities continued to be close, and owing to an arrangement with them it was possible for a native collector to be employed during the year under review at very little expense to the Research Station.

Enough collecting has now been done locally to give a sound systematic basis for ecological work. Incidentally, a mass of data on local bird-biology has been brought together, much of it relating to species hitherto known only from skins or to new forms. This information has been prepared for publication in the form of taxonomic and field notes. As collaborator on the systematic side I have been so fortunate as to secure Mr. W. L. Sclater, who has dealt with the Amani collections at the British Museum. In order to keep down the bulk of the notes, information known to be already on record elsewhere has generally been excluded. Publication will probably be completed about the end of 1932 and a certain number of copies will be available for those of our correspondents who are especially interested in the subject.

The following new forms have been described by Mr. Sclater from Amani during the year :—

Muscicapidae : Dioptrornis fischeri amani. Bull. B. O. C., Vol. 51, p. 112.

Sylviidae : Bradypterus brachypterus moreaui. Bull. B. O. C., Vol. 52, p. 57. *Apalis moreaui.* Bull. B. O. C., Vol. 51, p. 109.

Laniidae : Chlorophoneus nigrescens. Bull. B. O. C., Vol. 51, p. 110.

Ploceidae : Ploceus [*Symplectes*] *nicolli.* Bull. B. O. C., Vol. 52, p. 26.

Good progress has been made during the year with the detailed local survey. Now that the systematic position of the species encountered has been settled a start can be made to describe their distribution in terms of environmental factors. Their geographical distribution is regarded as of secondary and incidental importance, a point of view the reverse of that implicit in most work on African birds. For the ecologist it is unfortunate that past workers have been inevitably preoccupied with working out the ranges of species on the "political" map rather than on the botanical or the meteorological. Actually it is true that within wide bounds the geographical range of a species is conditioned by its degree of tolerance for various environmental factors, but the literature can be searched in vain for a precise statement of what the tolerance of any given species may be. In textbooks the range is given in geographical terms only, with the result that its concise statement masks an actual and often an essential and extreme discontinuity. The extreme discontinuity of the range of many African birds is indeed one of the most striking features of the ornithology of the Continent. It follows from two causes, the present climatic conditions with their secondary effects, and the past climatic changes. Geological research in East Africa in the last few years has added so much to our knowledge of climatic changes affecting Tropical Africa in geologically recent (Pleistocene) times that it is possible to utilize its conclusions to attack some of the general problems of discontinuous range, which indeed apply, not to birds only, but to all forms of life. A paper on the subject has been prepared.

Nearly a thousand tubes of stomach-contents are now available for examination and it has been possible to include a few particulars of bird-food in the field notes referred to above. As the process of exact determination is slow and highly expert, the prospect of its ever being done for all the species represented is remote. A special effort has however been made to work out the food of the Red-billed Oxpecker (*Buphagus erythrorhynchus*). The bird is generally regarded as of considerable economic importance and it is the more surprising that neither the British Museum authorities nor the Imperial Bureau of Entomology has been able to give references to any scientific account of this bird's food. It has been found possible to obtain 50 stomachs from a variety of localities. A greater number would have been desirable but difficulty has been experienced in procuring material. Examination of the whole series has practically been completed and it is hoped to publish the results shortly. Grateful acknowledgment is due to the Entomologist at the Veterinary Research Laboratories, Kabete, for identification of the ticks found in the stomachs, and to the Chief Veterinary Research Officer for allowing it to be undertaken.

Meteorological observations have been continued during the year at spots selected as typical of two types of forest and one, for comparative purposes, immediately outside the forest wall. As no meteorological data for the interior of an African forest have been published and very little is known of the climate under any form of heavy natural shade the interest of the results obtained is not confined to the original purpose for which the observations were started.

Advantage was taken of local leave to examine in some detail a narrow segment of Kilimanjaro from 4,000 to 14,000 feet. It is a curious fact that although Kilimanjaro is perhaps the most accessible of all the great African peaks no important contribution to its ornithology appears to have been made in the present century except by Sjöstedt, who worked in 1906.

At the beginning of the year the Game Warden of Tanganyika Territory asked that advice might be given on the preservation of a collection of birds stored at Game Department Headquarters, then at Kilosa. The journey was made by road in September, as soon as communication was restored after the rains. Opportunity was taken on the way to make a rapid traverse of the Nguru Mountains in order to compare altitudinal zonation there with what had already been learnt in the Usambara Mountains. The collection was found to consist of about 1,300 skins, for the most part in good condition. About 60 were judged to be of particular interest by reason of their locality or their intrinsic rarity. As the future of the collection appeared to be somewhat uncertain it was suggested to the Tanganyika Government that the possibility of housing these particular specimens in the British Museum might be considered. This has now been done. Recommendations were made for the preservation of the main part of the collection locally; it would provide useful material if a natural history museum were ever established in the Territory.

R. E. Moreau.

REPORT OF THE SUPERINTENDENT OF PLANTATIONS.

The Superintendent of Plantations returned from leave on 15th September, 1931, and the Engineer-Mechanic proceeded on leave on 26th November, 1931.

GENERAL.

Immediately on his return from leave the Superintendent of Plantations took over the harvesting of the Kwamkoro coffee crop. As soon as this was completed he resumed charge of the construction and maintenance work at Amani. Most of the work of the plantations and nursery was necessarily left to the Assistant Superintendent.

CONSTRUCTION AND MAINTENANCE.

Electricity Supply.

The chief work on the electricity supply has been the removal of all wooden standards on the high tension line and their replacement with double iron rail standards. This was necessitated on account of the wooden standards being found to be badly infested with termites.

Direct Current Generator.

A room has been built adjoining the workshops and a motor generator installed to supply direct current of 110 volts to the laboratories of officers who require it.

Distilling Plant.

A locally constructed distilling plant sufficient to supply distilled water for all the needs of the scientific officers has been installed.

Laboratories, Offices, and Quarters.

General improvements and repairs to buildings and equipment have been carried out in the laboratories as required. The outbuildings near the main office have been reconditioned and fitted with shelves and cupboards for use as stores for library, scientific, and office materials. The old German pot culture shed has been reconditioned and enlarged and taken into use for the purpose of pot experiments. The small greenhouse near the workshops has also been made serviceable. The large drying shed removed from its site near the laboratories has been re-erected in the nursery.

All houses of officers who proceeded on leave during the year were redecorated and repairs carried out where necessary. New quarters were built for the Indian carpenter in the Amani village. The housing conditions of the Amani native labour have received considerable attention. Many dilapidated huts have been pulled down and new ones erected, and the whole village made more open and sanitary. A new native hospital has been built, but owing to the carpenter being otherwise occupied the inside work is not yet complete.

Roads.

A distinct improvement in road communication has to be recorded. The Sigi Railway, having functioned as such for three months during the past eight or nine years, has now been definitely abandoned and the track converted into a motor road. The greater part of the work has been done under the supervision of the Superintendent of Plantations on behalf of the Public Works Department. The bridges have all been concreted with the exception of the three-span bridge over the Kihuhwi River which has Mvule decking.

Although the road has not yet been opened to general traffic the main work is practically complete. It leaves the old road from Muhesa at Mile 4 and reduces the distance between Amani and Muhesa from 24 to 20 miles. The road having been in the first instance prepared for the railway traffic, the gradients are easy, while the metalling available makes it practically an all-weather road.

Transport.

The transport of all materials for the Station has been carried out by the Chevrolet lorry, while the six-wheeled Thornycroft has been utilized in the transport of Mvule logs to the sawmill at Kwamkoro.

Kwamkoro Coffee Estate.

With the exception of the plots taken over for experimental purposes, work on the Kwamkoro Coffee Estate has been confined to the cleaning necessary to facilitate the picking of the crop. Twelve tons of parchment coffee and two tons of clean coffee were harvested.

GENERAL PLANTATION WORK.

As anticipated in the last Report, a much greater amount of supervision and labour has been available for plantation and nursery work.

Improvements have been carried out in the nursery which will contribute considerably to more efficient working. The reconditioned greenhouse has been in constant use for propagating economic plants and experiments in the grafting of coffee in the seedling stage.

Experiments in grafting *Coffea arabica* on various other species in the nursery beds and on old coffee plants in the plantations have been quite successful and much interesting and valuable information has been obtained.

Two large plots of sisal have been planted each from the bulbils of an individual plant, and much other work has been done for the Geneticist and the Plant Pathologist.

An old plantation of *Funtumia elastica* was cleared and a collection of native banana varieties planted. With the assistance of the Agricultural Officers, these were collected from the Moshi, Arusha, Lushoto, and Tanga Districts and locally. Altogether, 278 setts were planted, consisting of 82 groups, but investigation will probably show that little more than a third of that number are distinct varieties.

Two hundred plants have been raised from selected trees of Criollo cacao, obtained from the old plot at Sigi. Sites have been prepared for planting them during the present rains.

The plantings of *Ceiba pentandra* and *Hydnocarpus wightiana*, referred to in the last Report, continue to make good progress.

For the first time one plant of *Aleurites Fordii* flowered last November, the truss consisting of three female flowers. A few scattered plants made a healthy and satisfactory amount of growth and the general state of the plants is slightly more encouraging. It was proposed to experiment with grafting seedling *Aleurites Fordii* on seedling *Aleurites moluccana*, but the failure of the fresh seeds of *A. moluccana* to germinate completely frustrated this plan.

A number of sturdy seedlings of *A. Fordii* are in the seed beds ready for planting out with a view to further cultural experiments. The few *Aleurites montana* are very promising. The two plants left in the original seed bed, now 21 months old, are well-balanced healthy trees of over 12 feet.

CINCHONA.

Forty bales of Cinchona bark, consisting of eighteen *C. Ledgeriana*, twelve *C. Succirubra*, and ten of the hybrid between these two species were prepared and sent to England. A further twenty bales have been prepared and are ready for despatch.

PLANT AND SEED INTRODUCTION.

96 packets of seeds.
20 lb. *Aleurites Fordii*.
97 plants.
229 Banana setts.
Planting material of 11 different species of plants.

Among the plants of special interest received were *Hibiscus Sabdariffa* var. *altissima* (Roselle Hemp), *Boehmeria tenacissima*, (Ramie Fibre), and *Cephaelis Ipecacuanha* (Ipecacuanha).

PLANT AND SEED DISTRIBUTION.

466 plants.
1,461 cuttings.
467 packets of seeds.
57 lb. coffee seed.
198 lb. cover crop and other small seeds.
412 lb. rhizomes *Boehmeria nivea*.
800 suckers of *Musa textilis*.

F. M. Rogers,
Superintendent of Plantations.

REPORT OF THE SECRETARY AND LIBRARIAN.

The general office work calls for no comment.

As both the Secretary and Librarian and his Assistant were present at the Station throughout the year it was possible for full attention to be given to Library work. Excellent progress was made with the classified subject index, the small beginnings of which

were referred to in last year's Report. The index now contains about twenty thousand references, which are being added to steadily. It is estimated that well over half the important references in the Library have been extracted and the chief periodicals are being indexed currently. A good deal of assistance in elucidating foreign publications has been given during the year, and the Assistant Secretary has prepared translations of several German and Dutch papers.

The Carnegie grant mentioned in last year's Report has been of invaluable assistance in supplying the deficiencies in the Library. Many long sets of periodicals have been purchased during the year and, in addition, 152 books.

The Library now contains over seven thousand bound volumes and several thousand pamphlets. It is recognized that unless its resources are known they cannot be utilized to the full extent by workers in East Africa generally. Under present conditions there is, of course, no possibility of issuing a catalogue. The periodicals available for consultation and loan can however be indicated. In the first place, the Library possesses more or less complete sets of all the Journals, Bulletins, etc., issued by the Agricultural Departments throughout the Colonial Empire, and of the publications of the various Imperial Bureaux. In addition, series are obtained from agricultural research stations throughout the world by exchange, and periodicals dealing with every aspect of agriculture, as distinct from animal husbandry, are purchased. A summary list of the most important extra-Colonial publications available appears in this Report as Appendix B. With few exceptions they are represented by long, or complete, series.

R. E. Moreau,
Secretary and Librarian.

APPENDIX A.

FINANCIAL STATEMENT FOR THE YEAR ENDED 31st MARCH, 1932.

East African Agricultural Research Station.

REVENUE.

	£	£
Contribution, Empire Marketing Board	6,000	
„ Tanganyika Territory	6,000	
„ Uganda	1,800	
„ Kenya	1,700	
„ Zanzibar	1,200	
„ Northern Rhodesia	300	
„ Nyasaland	300	
	17,300	
Contribution, Empire Marketing Board, Balance for 1929–30	150	
Levy on Salaries	164	
Amani Local Revenue	342	
		17,956

EXPENDITURE.

Personal Emoluments :—		
Pay	10,840	
Pensions Contributions	1,505	
Passages	654	
Other Charges :—		
Laboratories	1,018	
Library	385	
Office, Telephones, and Contingencies	196	
Labour and Artisans	1,372	
Materials	440	
Freight and Transport	404	
Travelling	491	
		17,305
Net Saving on the year's working		£651
Balance of Capital Account, to be met from Recurrent Revenue		277
Credit Balance on year's working		374
Debit Balance brought forward from 1930–31		643
Debt on 31st March, 1932		£269

Kwamkoro Coffee Estate.

REVENUE.

	£	£
Sale of Coffee		931

EXPENDITURE.

Manager's Pay	100	
Labour	375	
Materials	5	
Freight and Transport	112	
Travelling	34	
	626	
Ex gratia payment to Manager*	152	
		778
Profit		£153†

* On termination of appointment, by special instruction of the Secretary of State.

† The actual profit amounted to £305. See preceding note.

APPENDIX B.

THE MORE IMPORTANT PERIODICALS AVAILABLE IN THE LIBRARY.

NOTE.—*The Library contains practically complete sets of the Journals, Bulletins, Year-books, etc., issued by all the Agricultural Departments coming under the Colonial Office, and of the publications issued by the Imperial Bureaux. It has not been thought necessary to include these individually in the list given below.*

Australia—
Journals, Bulletins, and Pamphlets, of the Council for Scientific and Industrial Research.
Colonial Sugar Refining Company, Agricultural Reports.

Belgium—
Revue de Zoologie et de Botanique Africaine.

Belgian Congo—
Bulletin Agricole du Congo Belge.

British West Indies—
West Indian Bulletin.
Agricultural News.

Ceylon—
Annals of the Royal Botanic Gardens.
Tea Quarterly.
Tea Research Institute Bulletins.
Tropical Agriculturist.

Dutch East and West Indies—
Publications of the Department of Agriculture and of the individual Research Stations.

Egypt—
Ministry of Agriculture, Technical and Scientific Service Bulletins.
Royal Agricultural Society Bulletins.

Federated Malay States—
Rubber Research Institute of Malaya publications.
Malayan Agricultural Journal.

France—
L'Agronomie Coloniale.
Annales des Epiphyties.
Bulletin de la Société Mycologique (to 1914 only).
Revue de Pathologie Végétale et d'Entomologie Agricole.
Revue de Botanique Appliquée et d'Agriculture Tropicale.

Germany—
Annales Mycologici (to 1914 only).
Annal der Chemie
Arbeiten aus der Biologischen Reichsanstalt für Land und Forstwirtschaft.
Berichte der Deutschen Botanischen Gesellschaft.
Berichte der Deutschen Chemischen Gesellschaft.
Berliner Entomologische Zeitschrift.
Botanische Jahrbücher.
Centralblatt für Bakteriologie.
Chemisches Zentralblatt.
Deutsche Entomologische Zeitschrift.
Düngungsversuche in den Deutschen Kolonien.
Jahresberichte über die Fortschritte auf dem Gesamtgebiete der Agrikultur Chemie.

Germany—*cont.*
Jahresbericht über der Entwickelung der Deutschen Schützgebieten.
Mitteilungen aus den Deutschen Schützgebieten.
Kolloidchemische Beihefte.
Phytopathologische Zeitschrift.
Tropenpflanzer.
Zeitschrift für Angewandte Entomologie.
Zeitschrift für Botanik.
Zeitschrift für Induktive Abstamms- und Vererbungs-Lehre.
Zeitschrift für Pflanzenkrankheiten.
Zeitschrift für Pflanzenzüchtung.
Zeitschrift für Wissenschaftliche Insektenbiologie.

Hawaii—
Hawaiian Sugar Planters' Association publications.

Holland—
Instituut voor Phytopathologie, Mededeelingen.
Tijdschrift over Plantenziekten.

India—
Agricultural Journal of India.
Agricultural Ledger.
Agriculture and Livestock in India.
Agricultural Research Institute, Pusa, publications.
Indian Forest Memoirs.
Indian Journal of Agricultural Science.
Memoirs of the Department of Agriculture in India.
Records of the Botanical Survey of India.
Review of Agricultural Operations in India.

International—
International Bulletin of Plant Protection.
International Society of Soil Science publications.

Italy—
Bollettino della R. Stazione di Patalogia Vegetale.
Revista di Pathologia Vegetale.

Japan—
Journal of the College of Agriculture, Tokyo.

Philippines—
Bureau of Agriculture publications.
Journal of Science.
Philippine Agricultural Review.

Sudan—
Department of Agriculture publications.
Wellcome Tropical Research Laboratories publications.

Trinidad—
Memoirs of the Cotton Research Station.
Memoirs of the Imperial College of Tropical Agriculture.
Froghopper Investigation Committee Proceedings.
Tropical Agriculture.

Union of South Africa—
Farming in South Africa (and its predecessors).
Department of Agriculture Bulletins, etc.
Bothalia.
South African Journal of Science.
Transactions of the Royal Society of South Africa.
South African Botanical Survey Memoirs.

United Kingdom—

Agricultural Research in (Year).
Analyst.
Annals of Applied Biology.
Annals of Botany.
Annual Reports of the Progress of Chemistry.
Biological Reviews.
British Chemical Abstracts.
Bulletin of Entomological Research.
Bulletin of the Imperial Institute.
Bulletin of Miscellaneous Information, Kew.
Chemistry and Industry.
East Malling Research Station Reports.
Empire Cotton Growing Corporation, Review etc.
Empire Marketing Board publications.
Geographical Journal
International Sugar Journal.
Journal of Agricultural Science.
Journal of the Ministry of Agriculture.
Journal of the Chemical Society.
Journal of Ecology.
Journal of Animal Ecology.
Journal of Experimental Biology.
Journal of Genetics.
Journal of the Linnean Society.
Journal of Pomology and Horticultural Science.
Journal of Scientific Instruments.
Long Ashton Research Station publications.
Nature.
New Phytologist.
Oxford Forestry Memoirs.
Review of Applied Entomology, Series A and B.
Review of Applied Mycology.
Rothamsted Memoirs of Agricultural Science.
Royal Society Proceedings and Transactions B.
Shirley Institute Memoirs.
Transactions of the British Mycological Society.

United States of America—

Selections of the Bulletins, etc., published by the Agricultural Experiment Stations of the several States in the Union and also of Porto Rico, Guam, and Hawaii.
U.S. Department of Agriculture Bulletins, Circulars, etc., including those of Divisions now superseded by the general series.
American Journal of Botany.
American Naturalist.
Annals of the Missouri Botanical Garden.
Biological Abstracts.
Botanical Abstracts.
Botanical Gazette.
Boyce Thompson Institute for Plant Research publications.
Bulletin of the Torrey Botanical Club.
Carnegie Institute of Washington selected publications.
Chemical Abstracts.
Ecology.
Ecological Monographs.
Experiment Station Record.
Genetics.
Hilgardia.
Journal of Biological Chemistry.

United States of America—*cont.*

Journal of Agricultural Research.
Journal of the American Society of Agronomy.
Journal of Bacteriology.
Journal of Economic Entomology.
Journal of Heredity.
Mycologia.
Phytopathology.
Plant Physiology.
Quarterly Review of Biology.
Science.
Soil Science.
Tropical Research Foundation publications.
U. S. National Museum publications.

For the majority of the publications listed above long or complete sets are available.

APPENDIX C.

METEOROLOGICAL OBSERVATIONS.

Meteorological observations have been maintained on the experimental areas, and a number of rainfall records from surrounding estates have been collected by courtesy of the owners ; a summary of the observations for the year 1931 is set out below.

MONTHLY RAINFALL RECORDS FOR STATIONS NEAR AMANI.

Rainfall recorded in inches

Month.	*Amani.* 3,000′	*Kwamkoro.* 2,900′	*Ngua.* 3,300′	*Uhehe Kwamkoro.* 3,400′	*Bulwa.* 3,000′	*Tongwe.* 1,500′
January ...	3·48	4·40	3·82	2·98	3·25	3·22
February ...	6·78	8·03	7·38	7·95	8·96	7·10
March ...	7·54	10·07	6·08	5·53	11·30	8·84
April ...	13·65	15·99	16·23	15·86	8·58	8·82
May	22·30	33·43	29·98	28·62	25·21	19·18
June ...	2·68	5·26	6·62	3·65	4·15	1·80
July ...	3·01	3·68	3·77	2·49	3·70	2·64
August ...	4·01	5·33	4·01	3·56	7·18	2·88
September ...	3·15	4·61	3·72	3·12	2·54	2·86
October ...	3·69	5·71	5·28	4·31	3·33	3·82
November ...	6·07	2·55	1·80	3·25	4·27	2·28
December ...	8·53	5·12	3·58	4·45	11·94	7·03
Totals ...	84·89	104·18	92·27	85·77	94·41	70·47

RECORDS OF MINIMUM AND MAXIMUM TEMPERATURES.

Month.	*Amani.*		*Kwamkoro Uhehe.*	
	Means of Max. °F.	*Means of Min.* °F.	*Means of Max.* °F.	*Means of Min.* °F.
January	80·4	65·1	82·1	62·9
February	79·8	65·8	80·1	64·5
March	78·5	66·6	76·0	65·1
April	76·3	66·0	78·8	67·8
May	72·0	64·4	69·0	61·4
June	71·3	61·0	70·3	56·9
July	70·9	59·8	67·9	55·6
August	70·4	58·3	70·7	56·2
September	72·6	57·9	70·7	56·5
October	74·0	59·8	75·0	58·7
November ...	78·3	59·9	79·6	58·7
December	78·3	63·3	79·0	61·1
Annual means (max. plus min.÷2) ...	75·23	62·32	74·93	60·45

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